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# ANCESTRAL CANYONS OF THE SNAKE RIVER: GEOLOGY AND HYDROLOGY OF CANYON-FILL DEPOSITS IN THE THOUSAND SPRINGS AREA, SOUTH-CENTRAL SNAKE RIVER PLAIN, IDAHO

by

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## INTRODUCTION

The Quaternary history of the Snake River involves repeated canyon cutting, damming by basaltic lavas, canyon filling, and diversion of the river southward. Basaltic eruptions on the Snake River Plain (fig. 1) produced large volumes of lava that flowed generally south and west from their source areas. These lavas often encountered the Snake River, and in some instances filled segments of ancestral canyons, diverting the river. This caused the river to cut a number of canyons, each progressively farther south along the margins of successive canyon-filling lava flows (Malde, 1971). Between Milner Dam and King Hill (the Thousand Springs area; fig. 2) the Snake River intersects several ancestral canyons, providing excellent exposures of the canyon-filling deposits.

The Snake Plain aquifer discharges as springs from the north canyon wall throughout the Thousand Springs area. Inspection of spring sites where the transmitting lithology (aquifer) is exposed, shows that in nearly all cases the springs discharge from ancestral canyon-filling deposits. The Thousand Springs area (fig. 2) contains 11 springs or spring groups with yields greater than 100 cubic feet per second (Meinzer, 1927) (fig. 3). This two day trip will investigate canyon-filling deposits and their relationship to springs. Localities will be visited to observe geologic relations, various types of canyon-fill deposits, and major springs. Discussions will center on canyon-filling episodes, the regional hydrologic system, and local geologic control on springs.

## GEOLOGIC FRAMEWORK

The Snake River Plain is a broad, arcuate depression that extends more than 300 miles across southern Idaho (fig. 1). The central part of the Plain (the area of this field trip, fig. 2) is an area of low relief, where scattered volcanic vents rise a few hundred feet above the surrounding plain, and the Snake River canyon is incised several hundred feet below the plain. The surface of the plain is dominated by late Pleistocene basaltic lava flows and interbedded river and lake sediments of the Snake River Group. These late Pleistocene rocks were deposited unconformably on middle Cenozoic basalt flows and stream and lake sediments of the Idaho Group, and tuffs of the Idavada Volcanics (figs. 4, and 5). The Snake River enters the plain near Idaho Falls (fig. 1) and flows westward along the southern margin of the plain, a position determined by the basaltic lava flows that erupted near the axis of the Snake River Plain and flowed mainly to the south. This caused the river to be diverted progressively farther south along the margins of successive canyon-filling lava flows.

Basalt flowing into a canyon would first dam the river, forming a temporary lake upstream, and drying the river channel downstream. As lava continued to flow into the canyon the lava dam would grow in height and massive lavas would be deposited downstream from the dam. Lava flowing into the temporary lake upstream from the dam would be deposited as pillow lavas. These pillow lavas would accumulate to the highest level of the temporary lake and then be capped by massive subaerial lavas. If sufficient lava was available to completely fill a part of the canyon the river would be diverted around the margin of the lava flows and begin to excavate a new channel. Lake clays would also accumulate in the temporary lake until the basalt dam was breached or new channel excavation had proceeded to a level below that of the temporary lake.

Pillow lavas and basaltic sands resulting from the subaqueous deposition of basaltic lavas are generally unsorted, coarse grained, and poorly indurated, with extremely high porosity and hydraulic conductivity. Interconnection of numerous canyons resulting from this cut and fill process created the framework for an aquifer with very high transmissivity and extremely high storage capacity.

## HYDROLOGIC FRAMEWORK

The Snake Plain aquifer north of the Snake River underlies most of the eastern two-thirds of the Snake River Plain (fig. 1). The aquifer is composed of basaltic lavas interbedded with fluvial and lacustrine sediments of the Snake River Group. The top of the aquifer (water table) is typically less than 500 feet below the land surface, but exceeds 1,000 feet in a few areas. The gradient of the water table ranges from 2 to 25 feet per mile, averaging about 5 feet per mile (Mundorff and others, 1964). Pumping tests along with specific-capacity data indicate that the coefficient of transmissivity of the aquifer generally ranges from 1 to 20 million gallons per day per foot, but locally may be as much as 60 million gallons per day per foot (Mundorff and others, 1964). These pumping tests along with laboratory studies indicate the coefficient of storage for the aquifer averages about 5 percent, but may be as much as 10 percent in some areas (Mundorff and others, 1964).

The Snake Plain aquifer is in dynamic balance between recharge and discharge. Natural recharge depends on regional precipitation, while induced recharge depends largely on the amount of surface water diverted for irrigation. Prior to surface water diversion for irrigation, which began in 1900, few natural discharge (spring) records are available. The data that are available suggest that locally the water table rose 60-70 feet (Mundorff and others, 1964), and that total spring discharge increased 60 percent from an estimated 4,200 cubic feet per second in 1902 to 6,500 cubic feet per second by 1950 (fig. 6). Since 1950, artificial discharge (pumping) has increased significantly, however no significant effects in the natural discharge have been noted.

## ANCESTRAL CANYON-FILLING EPISODES

Geologic investigation along the Snake River canyon from Milner Dam to King Hill by Malde and Powers (1972), Malde (1965; 1971), Covington (1976), and more recent unpublished mapping by Covington and Weaver have identified five episodes of ancestral canyon filling and diversion of the Snake River southward. These episodes are here referred to by the name of the basalt that filled the former canyon. These basalts, from oldest to youngest, are: 1) the Madson Basalt; 2) the Malad Basalt; 3) the Thousand Springs Basalt; 4) the Sand Springs Basalt; and 5) the McKinney Basalt.

FIGURES 7A-F.--Maps of field trip area showing distribution of late Pleistocene canyon-filling lava flows and drainage changes caused by these lava flows. (B) Bliss, (H) Hagerman, (J) Jerome, (KH) King Hill, (TF) Twin Falls.

### Madson Basalt

The Madson Basalt erupted from an unidentified vent east of Bliss, and flowed westward, probably down an ancestral canyon of the Big Wood River, and entered an ancestral Snake River canyon near Bliss (fig. 7a). A dam formed across the Snake River, and the basalt flowed westward down the canyon nearly to King Hill. A shallow lake formed in the canyon upstream from the basalt dam and pillow lavas were deposited within the lake to an altitude of 3,050 feet. Madson flows subsequently filled the canyon with massive columnar basalt and spread southward across the sedimentary deposits of the Glenns Ferry Formation, displacing the Snake River southward. The Madson Basalt is now discontinuously exposed in the north wall of the present Snake River canyon from Hagerman downstream to Bancroft Springs (fig. 2). The maximum exposed thickness of Madson Basalt (nearly 200 feet) occurs in Malad Canyon where approximately 50 feet of pillow lavas are overlain by 150 feet of columnar basalt (STOP 14). Most of the flow from Malad Springs--1,195 $ft^3/s$ (U.S. Geological Survey, 1982)--is from the pillow lava facies of the Madson Basalt.

### Malad Basalt

The Malad Basalt as used in this report was named by Stearns (1936) for a thick exposure at the mouth of Malad Canyon. The Malad Basalt spread southward from its source at Gooding Butte and flowed into an ancestral canyon of the Snake River excavated along the southern margin of the Madson Basalt (fig. 7b). Initially a dam formed across the Snake River a few miles south of Bliss, and pillow lavas were deposited in the lake that formed upstream from the dam to an altitude of 3,170 feet. Columnar basalts filled the canyon downstream from the dam nearly to Bliss (STOP 15). Once the canyon was completely filled with lava, the Malad Basalt continued to spread southward across sedimentary deposits of the Glenns Ferry Formation and lava flows of the Banbury Basalt. The Malad Basalt is now nearly continuously exposed along the north wall of the present canyon from southeast of Hagerman downstream nearly to Bliss. All of the spring flow along Billingsley Creek (Billingsley Springs--166 $ft^3/s$, U.S.Geological Survey, 1982) is from the Malad Basalt. At Malad Canyon a substantial part of the flow from Malad Springs (1,195 $ft^3/s$, U.S. Geological Survey, 1982) is also from the Malad Basalt.

## Thousand Springs Basalt

The Thousand Springs Basalt spread westward from its source vent at Flat Top Butte north of Twin Falls. The flows from Flat Top Butte deposited pillow lavas and massive columnar basalt of unknown thickness in an ancestral canyon of the Snake River from Twin Falls downstream nearly to Hagerman, a distance of more than 30 miles (fig. 7c). Outcrop relations near Thousand Springs indicate that a canyon with a minimum depth of 120 feet existed at this location. Initially a dam formed across the river in the area north of Twin Falls, and massive columnar basalt began to fill the canyon downstream. As side canyons entering the main ancestral Snake River canyon from the south were dammed, lakes developed and pillow lavas were deposited in these canyons (STOP 7). Near Thousand Springs the basalt entered an existing lake in the ancestral Snake River canyon, standing at an altitude of approximately 3,070 feet. Pillow lavas were deposited to the level of the lake surface, and then capped by a thin subaerial flow (STOP 12). Eventually the main canyon completely filled with basalt and the lava flows spread southward and westward across older lavas of the Glenns Ferry Formation and Banbury Basalt. Pillow lavas deposited within side canyons can be seen at Crystal Springs (457 $ft^3/s$, U.S. Geological Survey, 1982) and Niagara Springs (STOP 7), (260 $ft^3/s$, U.S. Geological Survey, 1982). At Thousand Springs (STOP 12), (1,360 $ft^3/s$, U.S. Geological Survey, 1982) the springs can be seen emerging from pillow lavas of the Thousand Springs Basalt at the contact with the Banbury Basalt, into which the ancestral canyon was incised.

## Sand Springs Basalt

The Sand Springs Basalt flowed southwest from its source vent at an unnamed butte (butte 4,526) northeast of Twin Falls (fig. 7d). A dam formed across the river somewhere northeast of Twin Falls and massive columnar basalts proceeded to fill the canyon downstream to a location north of Hagerman, a distance of more than 36 miles (fig. 7d). Upstream from the basalt dam pillow lavas were deposited into a temporary lake to an altitude of about 3,675 feet before being capped by a thin subaerial lava flow. Side canyons entering the ancestral Snake River canyon from the south were also dammed, causing lakes to form and pillow lavas to be deposited in these canyons. Clear Lakes Springs (494 $ft^3/s$, U.S. Geological Survey, 1982), Briggs Springs (112 $ft^3/s$, U.S. Geological Survey, 1982), and Banbury Springs (126 $ft^3/s$, U.S. Geological Survey, 1982) are believed to discharge through pillow lavas deposited within side canyons. Sand Springs Basalt now forms the north canyon rim from east of Twin Falls to Sand Springs, with massive canyon filling outcrops exposed at Blue Lakes Alcove (STOP 9) and Sand Springs (STOP 5). These outcrops indicate that the ancestral canyon filled by Sand Springs Basalt was approximately the same depth as the present canyon.

## Wendell Grade Basalt

The Wendell Grade Basalt flowed west, across the unpland plains, from its source vent at Notch Butte (fig. 7e), and spilled into Billingsley Creek at a location east of Hagerman. No canyon-filling lava flows or springs are associated with the Wendell Grade Basalt.

## McKinney Basalt

The McKinney Basalt, erupted from McKinney Butte (fig. 7f), flowed south into an ancestral canyon of the Big Wood River at a location just north of Bliss. The basalt began to fill the Big Wood canyon and to flow downstream to the confluence with the Snake River a few miles west of Bliss. A dam formed across the Snake River, and the Snake River canyon began to fill with massive columnar basalt downstream nearly to King Hill (fig. 7f). Upstream from the basalt dam a deep lake formed within the Snake River canyon (Malde, 1982). This ancestral Snake River canyon, upstream from Bliss, was of nearly the same configuration and location as the present canyon, although slightly deeper. As eruption of the McKinney Basalt continued the ancestral Big Wood River canyon was completely filled, and the lava spread south across the plain, east of Bliss, toward the Snake River canyon. As the lava reached the ancestral Snake River canyon, east of Bliss, it cascaded over the north rim of the canyon into the lake created by the basalt dam downstream. As a result, a large "fan shaped" deposit of pillow lavas developed within the lake, eventually reaching an altitude of 3,150 feet. Lacustrine clays, now recognized as the Yahoo Clay (Malde, 1982), accumulated in the lake upstream from the pillow lavas. These clays filled the canyon to an altitude of 3,180 feet before the river began to excavate a new canyon along the southern margin of the McKinney Basalt flows. McKinney Basalt is now continuously exposed at the north canyon rim from Malad Canyon downstream to Bancroft Springs. Bancroft Springs, with a flow of 17 $ft^3/s$ (Thomas, 1968), emerges from the base of massive canyon-filling lavas near King Hill, and is the only major spring associated with the McKinney canyon-filling deposits.

## FIELD TRIP ROAD LOG: FIRST DAY

Ancestral Snake River canyon-filling deposits will be inspected and discussed in order of youngest to oldest. The first day will be devoted to the McKinney Basalt, and Sand Springs Basalt canyon-filling episodes and related springs. There will be a hike of moderate length (2 miles total distance) to exposures of an ancestral canyon wall and canyon-filling pillow lavas. Stops will be made to inspect the McKinney Basalt cascade zone and view massive canyon-filling flows of Sand Springs Basalt. Day will end in Twin Falls.

Begin road log mileage at STOP sign; Exit 125 to Pasadena Valley from eastbound Interstate Highway I-84.

| Mileage: Incremental | Mileage: Cumulative | Description |
|---|---|---|
| 0.0 | 0.0 | TURN RIGHT (south) from Interstate highway exit, then first LEFT (east) on Carnahan Road (frontage road) toward Pasadena Valley. |
| 3.4 | 3.4 | TURN LEFT (east) on Shoestring Road. |
| 0.8 | 4.2 | TURN LEFT (north) on farm road. Road passes farm buildings and bears right toward river. |

| Mileage Incremental | Cumulative | Description |
|---|---|---|
| 0.3 | 4.5 | STOP 1. Park on right side of road at first left turn. Walk east approximately 100 feet to top of hill overlooking the Snake River.<br><br>The massive, cliff-forming, basalt on far side of river is canyon-filling McKinney Basalt. The north and south canyon walls are concealed beneath the talus at their respective ends of the cliff. The small group of trees near the south end of the cliff marks the location of Bancroft Springs.<br><br>Return to Shoestring Road. |
| 0.3 | 4.8 | PROCEED STRAIGHT (south) on Shoestring Road. |
| 0.7 | 5.5 | LEFT FORK. Continue south on Shoestring Road. |
| 2.1 | 7.6 | Road climbs out of canyon. Small outcrop on left is McKinney Basalt that is "plastered" against sediments of the Bruneau Formation that form the highland to the south and west. |
| 0.7 | 8.3 | TURN LEFT (east) following the main Shoestring Road |
| 0.5 | 8.8 | Deer Gulch. Bruneau Formation overlies Glenns Ferry Formation. |
| 0.3 | 9.1 | LEFT FORK. Follow road toward canyon rim. |
| 1.9 | 11.0 | Pilgrim Gulch. Basalt in Glenns Ferry Formation is Deer Gulch lava. |
| 1.0 | 12.0 | Little Pilgrim Gulch. Baked zone below Deer Gulch lava of Glenns Ferry Formation. |
| 3.0 | 15.0 | Continuing along Shoestring Road. Note the cliff forming outcrops of Madson Basalt on north side of canyon. These are "windows" in the ancestral canyon filled by Madson Basalt. The basalt bench within the canyon is Banbury Basalt. The north rimrock is McKinney Basalt. |
| 3.6 | 18.6 | Tuana Gulch. Banbury Basalt beneath Glenns Ferry Formation. |

| Mileage Incremental | Mileage Cumulative | Description |
|---|---|---|
| 1.5 | 20.1 | SNAKE RIVER. Cross bridge. |
| 0.1 | 20.2 | TURN LEFT (west) at first road on north side of Snake River. Proceed along road to third gate. Please close gates. |
| 0.4 | 20.6 | STOP 2. Park next to fence and walk west along the river trail approximately one mile.<br><br>Yahoo Clay crops out along trail. Rounded boulders of Melon Gravel can be seen on the small knobs above the trail. McKinney Basalt pillow lavas also crop out above the trail, and blocks that have tumbled down the slope can be seen along the trail. Trail ends where the river bends to the right. Climb up slope to narrow bench about 50 feet above river. Looking downstream (west) the left (south) river bank is Banbury Basalt; the right (north) river bank is pillow lava of McKinney Basalt deposited within the lake impounded by a lava dam of McKinney Basalt that formed across the ancestral canyon a mile or so west of here. These pillow lavas reach an altitude of 3,120 feet here.<br><br>If you turn around to face upstream (east), an exposure of the ancestral canyon wall is directly in front of you in the north canyon wall. On the left (north) at eye level is the paleo-talus deposit that was present along the south ancestral canyon wall. Looking up, you can see the McKinney Basalt pillow lavas lapping against the paleo-talus. Ahead and slightly to the right is Banbury Basalt that formed the south ancestral canyon wall.<br><br>Return to vehicles and retrace route to main road. Please close gates. |
| 0.4 | 21.0 | TURN LEFT (north). Road climbs short grade onto toe of Bliss landslide, a landslide in the Glenns Ferry Formation (Malde, 1981), and bends right (east). |
| 1.0 | 22.0 | TURN RIGHT (southeast) onto (old) U.S. Highway 30. |

| Mileage Incremental | Mileage Cumulative | Description |
|---|---|---|
| 1.5 | 23.5 | Madson Basalt "windows" form lower cliff below rimrock of McKinney Basalt on left (east). |
| 1.0 | 24.5 | McKinney Basalt pillow lavas crop out along road. Small springs can be seen emerging from the pillow lavas above and below road. |
| 1.8 | 26.3 | TURN LEFT (northeast) Junction U.S. Highway 30. Highway climbs onto north canyon wall. McKinney Basalt pillow lavas crop out along highway. |
| 1.7 | 28.0 | STOP 3. Park at east end of scenic overlook turn out on south side of highway. Walk short distance down highway to outcrop of McKinney Basalt pillow lavas of the "cascade zone." Note the west dipping foreset bedding. These pillow lavas formed when McKinney Basalt cascaded over the canyon rim into a deep lake. |
| | | Return to vehicles and retrace route southeast along U.S. Highway 30. |
| 1.7 | 29.7 | Big Wood River. Cross river as it exits from Malad Canyon on the left (east). Massive basalt cliffs at the entrance to Malad Canyon are ancestral canyon filling flows of Malad Basalt. |
| 2.0 | 31.7 | Billingsley Creek. Fed by numerous springs upstream that emerge from the Malad Basalt. Average flow is approximately 180 $ft^3/s$. |
| 1.1 | 32.8 | Hagerman. Continue south through town. |
| 4.5 | 37.3 | SNAKE RIVER |
| 1.3 | 38.6 | STOP 4. Park in scenic turnout on right side of highway. Looking east across the river Magic Springs can be seen on the left cascading over the Banbury Basalt bench. On the right Thousand Springs issues from the Thousand Springs Basalt high on the canyon wall. The rimrock is Thousand Springs Basalt, unconformably resting on Banbury Basalt. |
| | | Continue south on U.S. Highway 30. |

| Mileage Incremental | Cumulative | Description |
|---|---|---|
| 1.2 | 39.8 | STOP 5. Turn left off highway, and park on road to gravel pit. Looking east across river a massive cliff of canyon filling Sand Springs Basalt can be seen. The north and south ancestral canyon walls are covered by talus at the north and south ends of the cliff.<br><br>Proceed south on U.S. Highway 30. |
| 2.5 | 42.3 | TURN LEFT (east). Follow road toward Banbury Hot Springs. |
| 1.4 | 43.7 | TURN LEFT (north). Follow road north along river to gate. |
| 0.8 | 44.5 | STOP 6. Park in turn-around at gate. Walk north 100 feet to top of hill. Looking east across the river Box (north) and Blind (south) canyons can be seen entering the Snake River canyon. North of Box canyon massive canyon-filling lavas of Sand Springs Basalt can be seen. South of Blind canyon the Snake River canyon wall is Banbury Basalt capped by Sand Springs Basalt. Springs that arise in Box and Blind canyons are from the Sand Springs Basalt. Looking farther south along the Snake River, Banbury Springs can be seen as a slight reentrant in the east canyon wall. Banbury Springs emerge from Sand Springs Basalt pillow lavas.<br><br>Return to vehicles and retrace route to main county road. |
| 0.8 | 45.3 | TURN LEFT (south). Follow road along river. Banbury Springs can be seen across river. |
| 2.8 | 48.1 | TURN LEFT (east). Continue to follow road along river. |
| 2.0 | 50.1 | Clear Lakes Springs. Looking north across the Snake River, you can see the springs and fish hatchery. The springs emerge from pillow lava of the Sand Springs Basalt. |
| 0.6 | 50.7 | TURN LEFT (north). Proceed north on county road toward Snake River. |

| Mileage Incremental | Mileage Cumulative | Description |
|---|---|---|
| 0.4 | 51.1 | SNAKE RIVER. Cross river and proceed up grade to north canyon rim. |
| 1.0 | 52.1 | Clear Lakes Springs and fish hatchery on left. Sand Springs Basalt pillow lavas crop out in road cut on right. |
| 1.0 | 53.1 | North Snake River canyon rim. Pillow lavas of Sand Springs Basalt can be seen in road cut at top of grade. |
| | | Follow main county road as it zig-zags north away from the canyon. |
| 1.8 | 54.9 | TURN RIGHT (east). Proceed east on Bob Barton Highway (Two lane county road). |
| 4.5 | 59.4 | TURN RIGHT (south) Road to Niagara Springs. Follow road over canyon rim, and down grade to Niagara Springs. |
| 3.2 | 62.6 | STOP 7. Park on left side of road at gate. Walk along boardwalk to spring overlook. Niagara Springs discharges approximately 280 $ft^3/s$ from the Thousand Springs Basalt. In the early 1900's Niagara Springs was partly diverted for irrigation of nearby pasture land and orchards. The Idaho Power Company began to develop the present fish hatchery in 1965, as part of a program to replace anadromus fish lost by construction of dams on the Snake River. As a result of nearly constant flow, water-quality, and temperature (58$^{o}$ F), steelhead trout can obtain as much as two years growth in one year at this facility. |
| | | Return to vehicle and retrace route to canyon rim. |
| 1.6 | 64.2 | STOP 8. North canyon rim. Park in pull out at canyon rim. Walk back down road to contact between Banbury Basalt and Sand Springs Basalt. |
| | | Return to vehicles and proceed north on county road. |
| 0.6 | 64.8 | TURN RIGHT (east) First intersection after leaving canyon rim. Proceed east on section line road. |

| Mileage Incremental | Mileage Cumulative | Description |
|---|---|---|
| 9.5 | 74.3 | TURN RIGHT (south) at STOP sign, and proceed south. |
| 3.0 | 77.3 | TURN LEFT (east) at STOP sign. Jerome Golf Course on the right. |
| 4.0 | 81.3 | TURN RIGHT (south) Junction U.S. Highway 93. |
| 0.5 | 81.8 | SNAKE RIVER. Cross river on Perrine Memorial Bridge. |
| 1.2 | 83.0 | HOLIDAY INN. Turn Left into parking lot on east side of Blue Lakes Blvd. |

END OF ROAD LOG: FIRST DAY

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## FIELD TRIP ROAD LOG: SECOND DAY

The second day will be devoted to the Sand Springs Basalt, Thousand Springs Basalt, Malad Basalt, and Madson Basalt canyon-filling episodes and related springs. The day begins with a short hike (1/2 mile total distance) to view the contact between an ancestral canyon wall and massive canyon-filling Sand Springs Basalt. Lunch will be in the Thousand Springs Power Plant park, where the collection flume will be seen. This short walk (1/4 mile total distance) along the collection flume will allow a close view of the Thousand Springs Basalt pillow lavas and the springs that discharge from the pillow lavas. Inspection of the Madson Basalt pillow lavas and the Malad Springs will also involve a hike of moderate distance (1 mile total distance) in Malad Canyon. The final hike of the day will be left to the participant, a short hike (1/4 mile total distance) to view Malad Springs from the canyon rim, or a moderate hike (1 1/2 miles total distance) to also view the collapse features along Malad Canyon. The day will end with the return trip to Boise.

Begin road log mileage at the Twin Falls Holiday Inn on Blue Lakes Blvd.

| Mileage Incremental | Mileage Cumulative | Description |
|---|---|---|
| 0.0 | 0.0 | TURN RIGHT (north) onto Blue Lakes Blvd. (U.S. Highway 93). |
| 1.2 | 1.2 | SNAKE RIVER. Cross river on Perrine Memorial Bridge. |
| 0.5 | 1.7 | TURN LEFT (west) at first intersection north of the Snake River. |

| Mileage Incremental | Mileage Cumulative | Description |
|---|---|---|
| 0.6 | 2.3 | TURN LEFT (south) onto gravel road to Blue Lakes Alcove overlook. |
| 0.1 | 2.4 | STOP 9. Park at alcove rim overlook. Blue Lakes alcove displays a cross section of an ancestral canyon filled with massive Sand Springs Basalt flows. Standing at the alcove rim, you can look down and slightly to the right to see the "weathered" appearing outcrops that formed the north ancestral canyon wall. Look across the alcove, the south ancestral canyon wall occurs at the "hairpin" curve on the road into the alcove. Blue Lakes Spring emerges from the rubble on the alcove floor, and has an average flow of 200 cubic feet per second. The alcove is a relic of the Bonneville Flood (Malde, 1968). <br><br> Return to main road. |
| 0.1 | 2.5 | TURN LEFT (west). Proceed to first intersection. |
| 0.8 | 3.3 | TURN LEFT (south) onto road to Blue Lakes Country Club. |
| 0.6 | 3.9 | STOP 10. Park on right side of road where the road bends left toward the alcove. Cross fence and walk west approximately 1,000 feet to small alcove. Standing on the east rim a clear contact between the south ancestral canyon wall and the massive canyon-filling Sand Springs Basalt can be seen in the opposite wall of the alcove. <br><br> Return to vehicles and retrace route to main county road. |
| 0.6 | 4.5 | TURN LEFT (west) at intersection with county road to Jerome. |
| 2.6 | 7.1 | TURN LEFT (south) at STOP sign, Jerome Golf Course on left. Proceed to canyon rim. |

| Mileage | | Description |
|---|---|---|
| Incremental | Cumulative | |
| 0.2 | 7.3 | STOP 11. Park at canyon rim. Walk along road into canyon to inspect Sand Springs Basalt pillow lavas. Looking east from first turn (left) as road descends into canyon, an ancestral canyon wall occurs beneath the talus on the opposite side of this reentrant. On the left massive, canyon-filling Sand Springs Basalt occurs, and on the right the older lavas that formed the ancestral canyon wall can be distinguished by their "bedded" and "weathered" appearance.<br><br>Return to vehicle and retrace route to county road to Jerome. |
| 0.2 | 7.5 | PROCEED STRAIGHT (north) at STOP sign, continue north on country road toward Jerome. |
| 3.4 | 10.9 | TURN LEFT (west) onto service road. |
| 0.6 | 11.5 | Service road bends left and becomes the Bob Barton Highway (two lane county road). |
| 13.8 | 25.3 | TURN RIGHT (north) at STOP sign. |
| 2.0 | 27.3 | TURN LEFT (west) following signs to Thousand Springs Power Plant. |
| 2.1 | 29.4 | TURN RIGHT (north) following signs to Thousand Springs Power Plant. |
| 0.4 | 29.8 | TURN LEFT (west) following signs to Thousand Springs Power Plant. |
| 0.4 | 30.2 | Canyon rim. Springs on right, after crossing over canyon rim, emerge from pillow lavas of the Thousand Springs Basalt. |
| 0.6 | 30.8 | STOP 12. Thousand Springs Power Plant. Park vehicles at the power plant park. Thousand Springs was first developed for irrigation between 1888 and 1890. During 1901-1902 an unsuccessful attempt was made to raise water to the canyon rim for irrigation. In 1906 an attempt to increase flow by driving tunnels along the contact where springs appear was also unsuccessful. Some of these tunnels can be seen along the present flume. An Arizona company completed |

| Mileage Incremental | Cumulative | Description |
|---|---|---|
| | | the first electrical generating plant at this site in 1911, and operated the plant until 1917 when the Idaho Power Company aquired the facility. The power plant was expanded to its present size and additional spring water aquired in 1920. |
| | | The springs emerge from pillow lavas deposited within an ancestral canyon of the Snake River when that canyon was filled with Thousand Springs Basalt. Thousand Springs has an average flow of 1,400 cubic feet per second. |
| | | Retrace route to main county road. |
| 1.0 | 31.8 | TURN LEFT (north). Follow road northward along canyon rim. |
| 3.3 | 35.1 | STOP 13. Park on right side of road at intersection. Yahoo Clay crops out in road cut. This clay was deposited in a deep lake that formed when McKinney Basalt dammed the Snake River a few miles west of Bliss. Deposits of this clay reach from present day river level to an altitude of 3,180 feet. |
| | | TURN RIGHT (north) at intersection. |
| 1.0 | 36.1 | TURN LEFT (west) at STOP sign. |
| 0.5 | 36.6 | TURN RIGHT (north) onto U.S. Highway 30. |
| 3.0 | 39.6 | Hagerman, continue north through town. |
| 3.0 | 42.6 | TURN RIGHT (east) onto gravel road into Malad Canyon. The original development at Malad Springs was by the Beaver River Power Company in 1911. The Idaho Power Company aquired the site in 1948 and placed the Upper Malad station into operation. The Idaho Power Company facilities now consist of two run-of-the-river developments, the Upper Malad and the Lower Malad generating stations. |

| Mileage Incremental | Cumulative | Description |
|---|---|---|
| 1.1 | 43.7 | STOP 14. Park at fence. Pass through pedestrian gate in fence and walk along road to the diversion structure. Madson Basalt pillow lavas occur at river level and discharge a major portion of Malad Springs flow, which averages 1,280 cubic feet per second.<br><br>Return to vehicles and retrace route to U.S. Highway 30. |
| 1.1 | 44.8 | TURN RIGHT (north) onto U.S. Highway 30. |
| 0.1 | 44.9 | BIG WOOD RIVER |
| 4.9 | 49.8 | TURN RIGHT (east) onto U.S. Highway 20 and 26. |
| 0.1 | 49.9 | TURN RIGHT (southeast) onto eastbound Interstate Highway I-84. |
| 6.2 | 56.1 | EXIT 147 to Tuttle. TURN RIGHT (west) following signs to Malad Gorge State Park. |
| 1.1 | 57.2 | STOP 15. Park in parking area. Walk across bridge and follow trail along rim approximately 1,000 feet. Basalt that forms rimrock on both sides of the canyon is Malad Basalt. Note the color change as water from Malad Springs enters the Big Wood River. Walk another 2,000 feet along canyon rim to overlook above diversion structure visited at STOP 14. Looking down canyon (west), large slump blocks of Malad Basalt can be seen collapsed into the canyon.<br><br>Return to vehicles and retrace route to Interstate Highway I-84. |

END OF ROAD LOG

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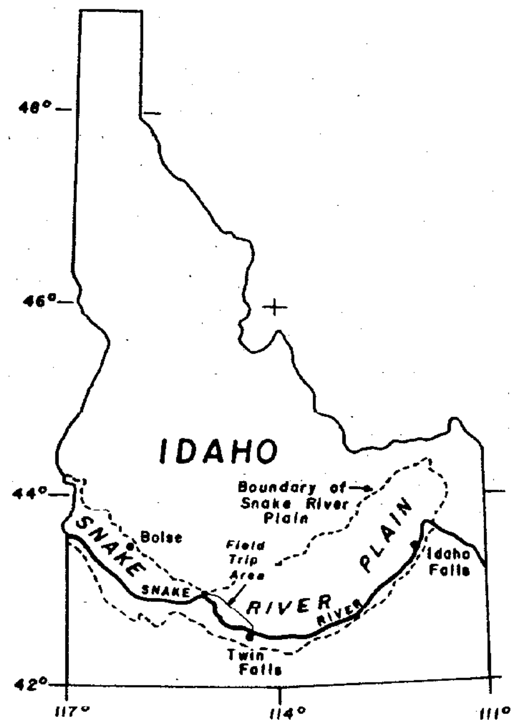


FIGURE 1.--Map of Idaho showing the location of the Snake River Plain and the area of the field trip.

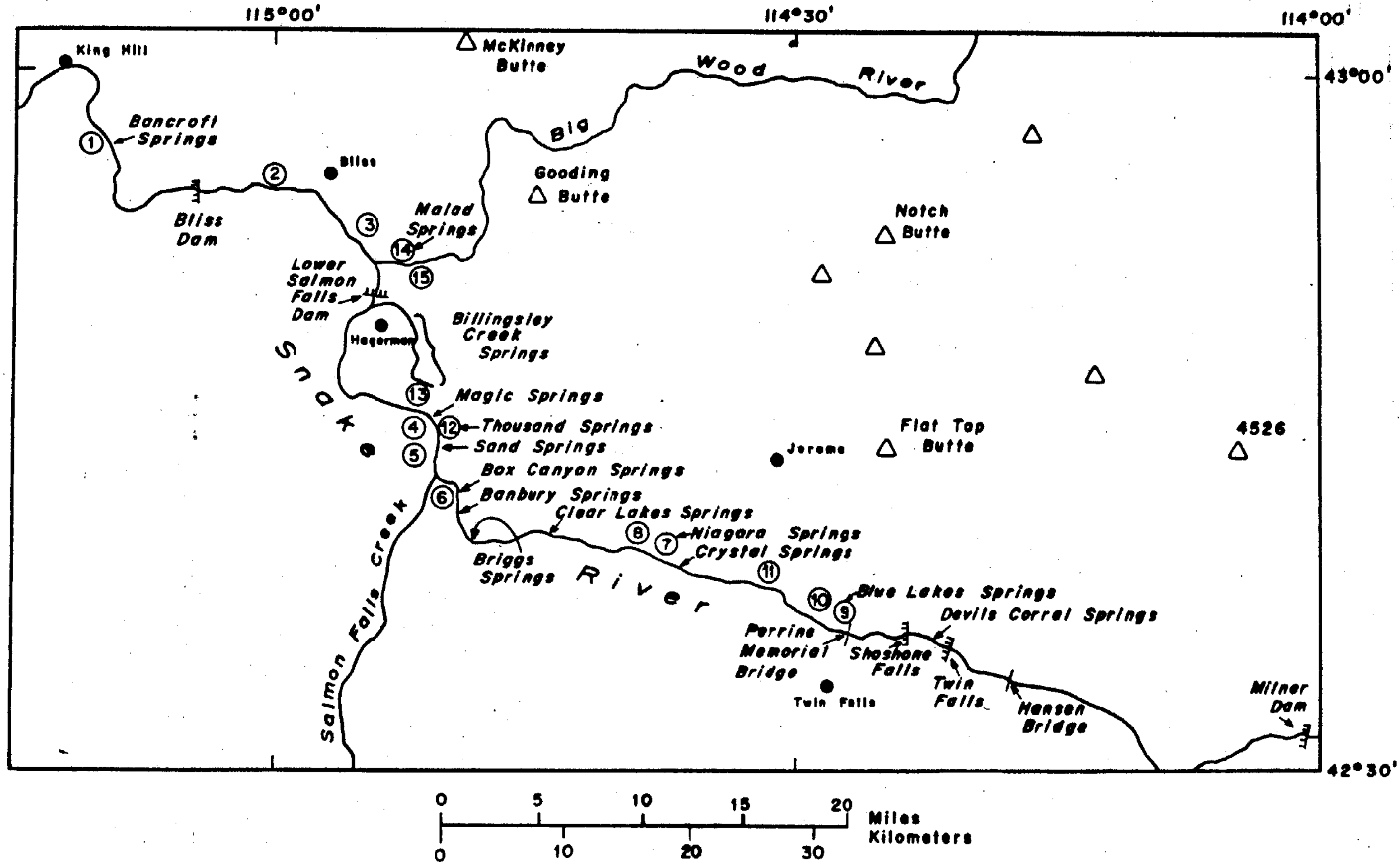


FIGURE 2.—Map showing major physiographic features of the field trip area, and numbered locations of field trip stops.

SPRING DATA

| Spring Name | Altitude (feet) | Discharge ft³/s | Date | Formation | Remarks |
|---|---|---|---|---|---|
| Bancroft Springs | 2,530 | 17 | 01-03-66 | McKinney Basalt | Several springs discharge from talus at base of cliff. Cliff is composed of massive canyon-filling McKinney Basalt more than 275 feet thick. Discharge records consist of one measurement made on January 3, 1966. No use of water between spring and Snake River. |
| Malad Springs | 2,850 to 3,090 | 1,195 | 03-13-81 | Madson Basalt and Malad Basalt | Springs issue at or below river level from pillow lava facies of the Madson Basalt and Malad Basalt for a distance of at least one mile along the Big Wood River. Discharge records discontinuous from 1899 to present. Almost entire flow is diverted for power generation and irrigation. |
| Billingsley Creek Springs | 3,055 to 3,138 | 166 | 03-09-81 | Malad Basalt | Springs discharge from pillow lava facies of Malad Basalt at contact with the Yahoo Clay along Billingsley Creek for a distance of 4 miles. Discharge records discontinuous from 1899 to present. Almost entire flow is diverted for power generation and irrigation. |
| Magic Springs | 2,951 to 3,072 | 185 | 07-13-21 | Thousand Springs Basalt | Springs, originally called Bickel Springs, discharge through talus from pillow lavas of Thousand Springs Basalt. Discharge records discontinuous from 1917 to 1931. Entire flow diverted for aquaculture. |
| Thousand Springs | 2,955 to 3,075 | 1,360 | 03-10-81 | Thousand Springs Basalt | Springs emerge from pillow lava facies of the Thousand Springs Basalt at contact with the Banbury Basalt for a distance of nearly one mile along Snake River. Records discontinuous from 1950 to present. Large part of flow diverted for power generation and aquaculture. |
| Sand Springs | 3,140 to 3,160 | 79.8 | 03-10-81 | Thousand Springs Basalt | Springs emerge from beneath low scarp in the Thousand Springs Basalt at contact with the Sand Springs Basalt 200 feet above the Snake River. Records discontinuous from 1902 to present. Large part of flow diverted for power generation and aquaculture. |
| Box Canyon Springs | 2,950 to 3,060 | 852 | 04-06-56 | Sand Springs Basalt | Springs discharge through talus from the Sand Springs basalt at several locations along the south side of Box Canyon. Discharge records consist of several estimates, but only one measurement. Part of flow is diverted for aquaculture. |
| Banbury Springs | 2,980 to 3,105 | 126 | 03-10-81 | Sand Springs Basalt | Springs discharge through talus from pillow lava facies of the Sand Springs Basalt. Discharge records discontinuous from 1902 to present. Small part of flow diverted for irrigation. |
| Briggs Springs | 3,025 to 3,035 | 112 | 03-11-81 | Sand Springs Basalt | Springs discharge through talus from pillow lava facies of the Sand Springs Basalt. Discharge records discontinuous from 1902 to present. Part of a flow diverted for irrigation. |
| Clear Lakes Springs | 3,010 to 3,070 | 494 | 03-12-81 | Sand Springs Basalt | Springs issue from pillow lava facies of the Sand Springs basalt. Discharge records discontinuous from 1902 to present. Part of flow is diverted for irrigation, but most of flow is used for aquaculture and power generators. |
| Niagara Springs | 3,140 to 3,180 | 260 | 03-11-81 | Thousand Springs Basalt | Springs discharge from pillow lava facies of the Thousand Springs Basalt. Discharge records discontinuous from 1902 to present. Entire flow used for aquaculture. |
| Crystal Springs | 3,040 to 3,100 | 457 | 03-11-81 | Thousand Springs Basalt | Springs discharge from pillow lava facies of the Thousand Springs Basalt. Discharge records discontinuous from 1902 to present. Entire flow used for aquaculture. |
| Blue Lakes Spring | 3,300 | 190 | 03-12-81 | Sand Springs Basalt | Spring discharges through rubble on floor of alcove at base of cliff 300 feet high. Cliff consists of massive canyon-filling Sand Springs Basalt. Discharge records discontinuous from 1902 to present. Part of flow diverted for aquaculture. |
| Devils Corral Springs | 3,440 to 3,450 | 39.9 | 03-09-81 | Sand Springs Basalt | Springs discharge through talus from pillow lava facies of the Sand Springs Basalt. Discharge records discontinuous from 1902 to present. No use of flow between spring and Snake River. |

FIGURE 3.--Chart showing general spring data for spring locations shown in figure 2.

| AGE | | | STRATIGRAPHIC UNIT | DESCRIPTION |
|---|---|---|---|---|
| Holocene | | | Surficial Deposits | Includes modern stream alluvium, wind blown silt, talus deposits, and landslide deposits. |
| Pleistocene | Late | Snake River Group | Older Alluvium and Gravel | Includes pebbly and gravely, terrace deposits and the Melon Gravel that resulted from the catastrophic outflow from Pleistocene Lake Bonneville. |
| | | | | CANYON CUTTING OF MODERN CANYON |
| Pleistocene | Late | Snake River Group | Yahoo Clay | Lacustrine clays deposited within lake resulting from damming of the Snake River by McKinney Basalt. Includes the Crowsnest Gravel which forms a thin veneer on the clay in the Hagerman valley. |
| Pleistocene | Late | Snake River Group | McKinney Basalt | Erupted from vent at McKinney Butte, flowed southward filling ancestral canyons of the Big Wood River and the Snake River. |
| | | | | CANYON CUTTING |
| Pleistocene | Late | Snake River Group | Wendell Grade Basalt | Erupted from vent at Notch Butte, flowed westward to cascade over rim of Snake River Canyon into Billingsley Creek. |
| Pleistocene | Late | Snake River Group | Sand Springs Basalt | Erupted from vent at butte 4526, flowed south and west filling an ancestral Snake River canyon from east of Twin Falls to north of Hagerman. |
| | | | | CANYON CUTTING |
| Pleistocene | Late | Snake River Group | Thousand Springs Basalt | Erupted from vent at Flat Top Butte, flowed south and west filling an ancestral Snake River canyon from north of Twin Falls to south of Hagerman. |
| | | | | CANYON CUTTING |
| Pleistocene | Late | Snake River Group | Malad Basalt | Erupted from vent at Gooding Butte, flowed south and west filling an ancestral Snake River canyon from Hagerman to Bliss. |
| | | | | CANYON CUTTING |
| Pleistocene | Late | Snake River Group | Madson Basalt | Erupted from unknown source vent, flowed west filling ancestral canyons of the Big Wood River and the Snake River. |
| | | | | CANYON CUTTING |
| Pleistocene | Early | Idaho Group | Silt, sand, and gravel | Materials derived mainly from the highlands south of the Snake River Plain and deposited on the upland surface south of the Snake River; includes the Bruneau Formation, and Tuana Gravel. |
| | | | | PLANATION OF BASIN DEPOSITS; FAULTING |
| Pleistocene / Pliocene? | Early / Late | Idaho Group | Glenns Ferry Formation | Basin filling deposits of poorly consolidated clay, silt, sand, and gravel interbedded with minor lava flows. |
| | | | | BLOCK FAULTING AND EROSION |
| Miocene | Late | Idaho Group | Banbury Basalt | Lava flows interbedded locally with stream and lake sediments. |
| | | | | SUBSIDENCE OF SNAKE RIVER PLAIN |
| Miocene | Late | | Idavada Volcanics | Ash-flow tuffs and rhyolite lavas. |

Modified from Malde and Powers, (1972)

FIGURE 4.--Generalized stratigraphy of the field trip area.

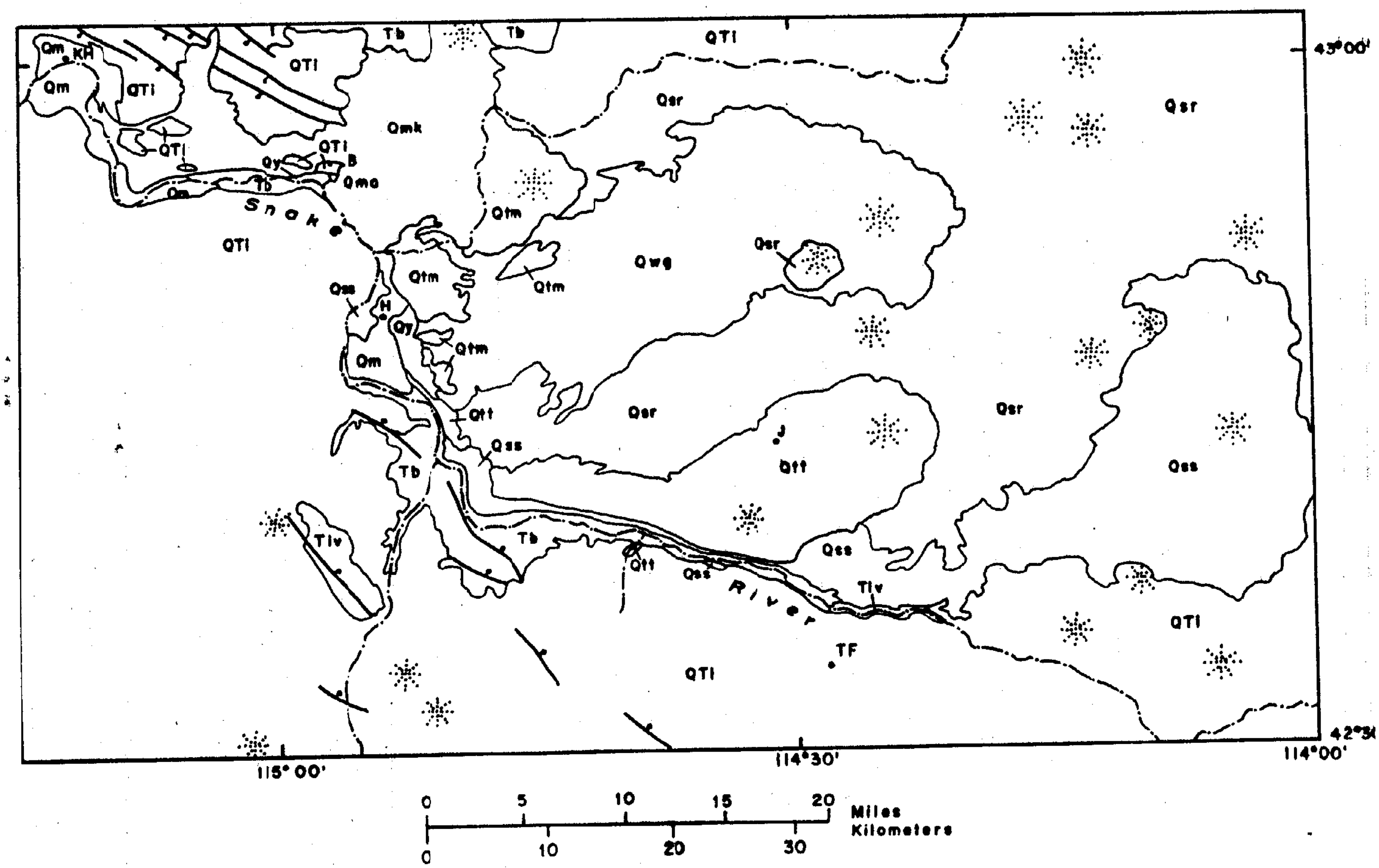


FIGURE 5.--Generalized geologic map of the field trip area. (B) Bliss, (H) Hagerman, (J) Jerome, (KH) King Hill, (TF) Twin Falls. Modified from Malde and others (1963).

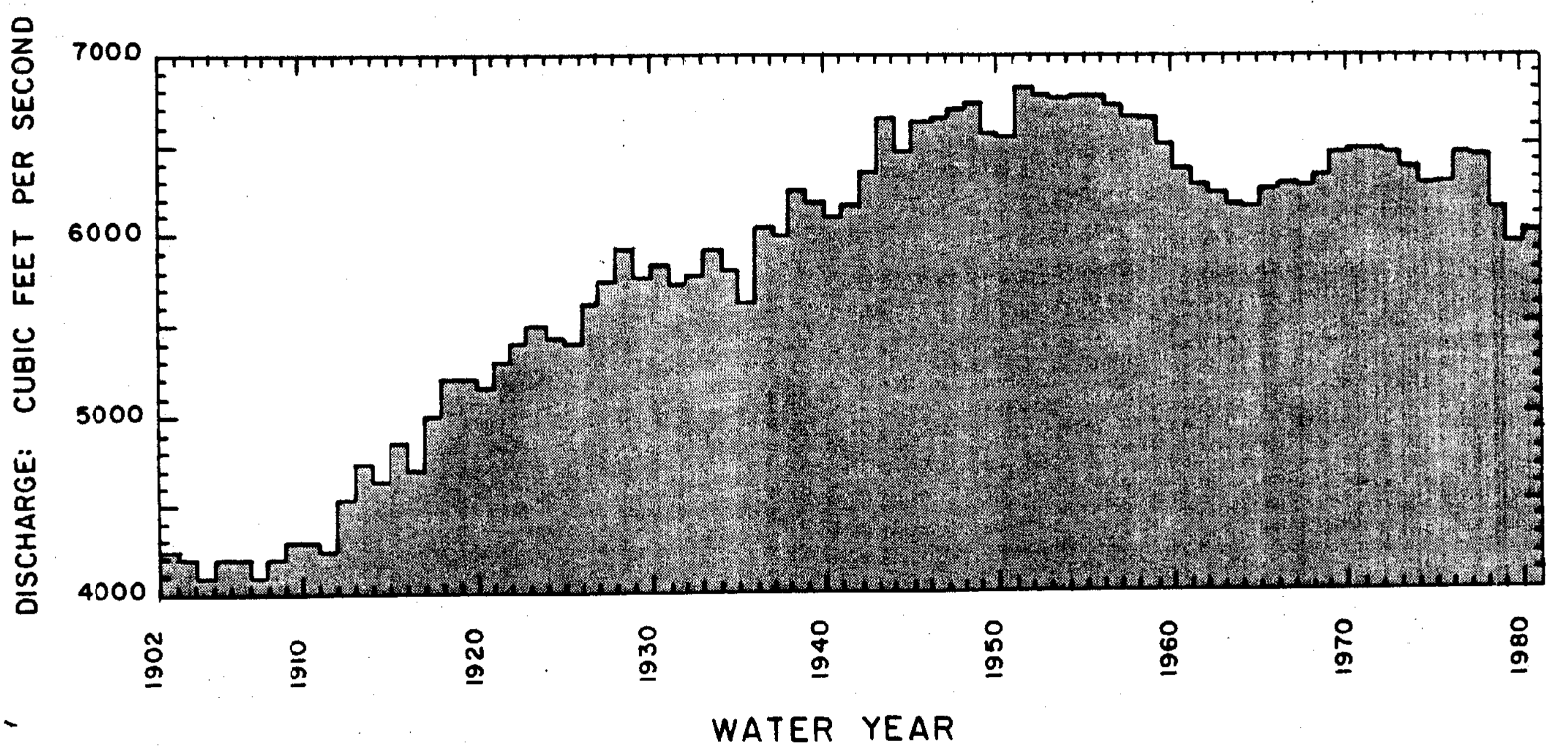


FIGURE 6.--Graph showing total north-side spring flow between Milner Dam and King Hill: 1902 to 1980. Modified from Kjelstrom (1984).

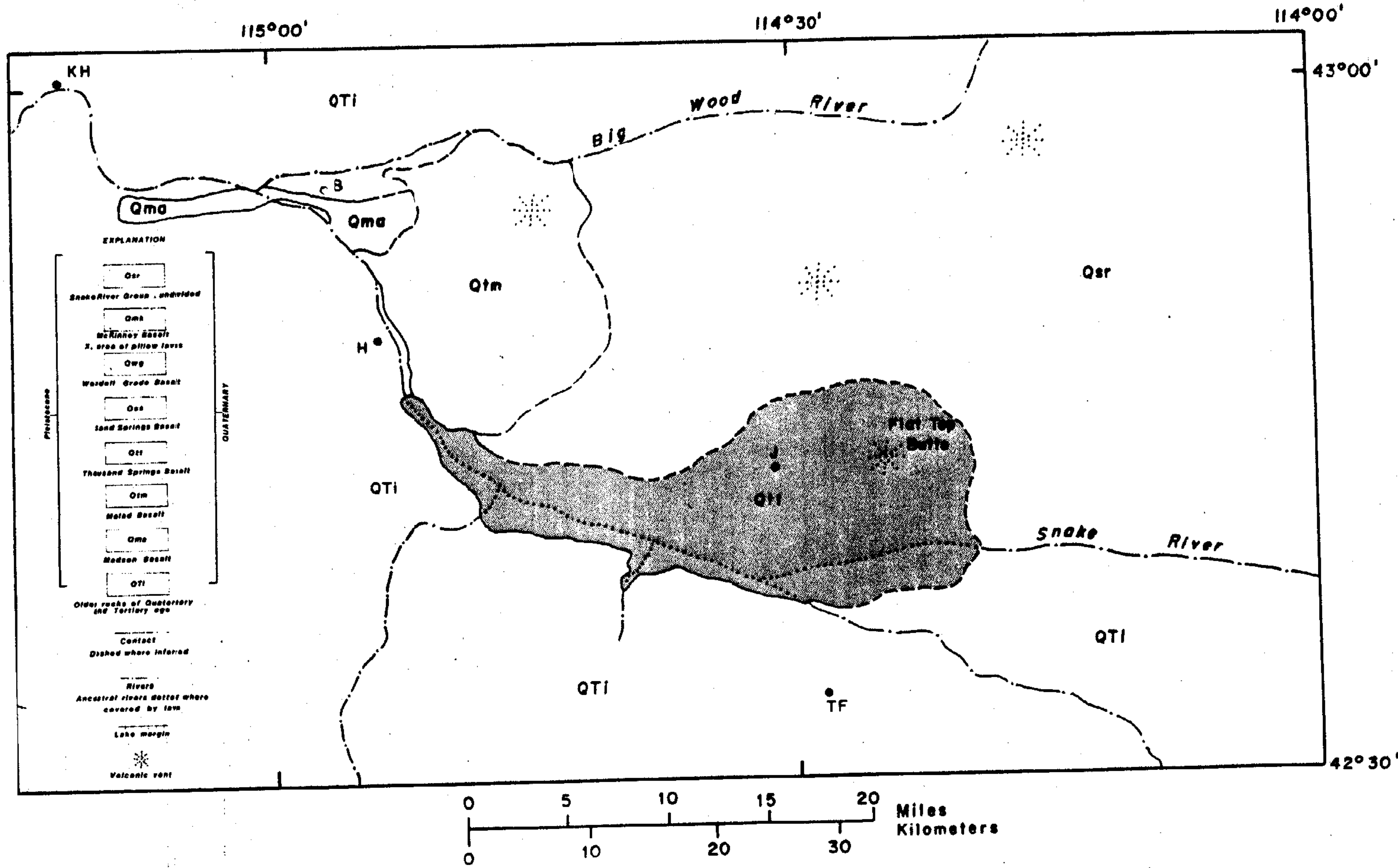


FIGURE 7C.--Thousand Springs Basalt from vent at Flat Top Butte fills ancestral Snake River canyon for a distance of more than 30 miles. Diverts Snake River southward.

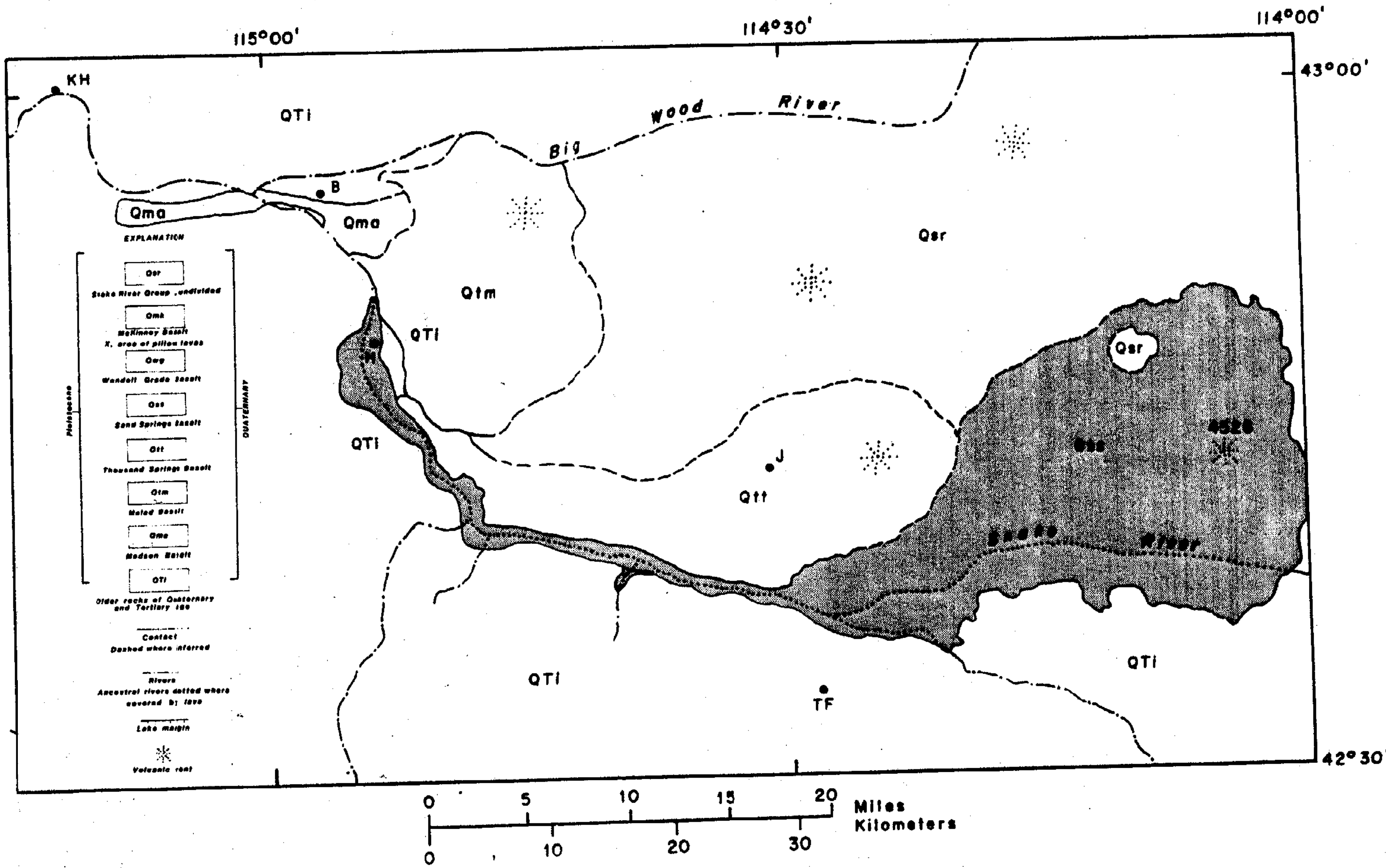


FIGURE 7D.--Sand Springs Basalt from vent at Butte 4526 fills ancestral Snake River canyon for distance of more than 36 miles. Diverts Snake River southward.

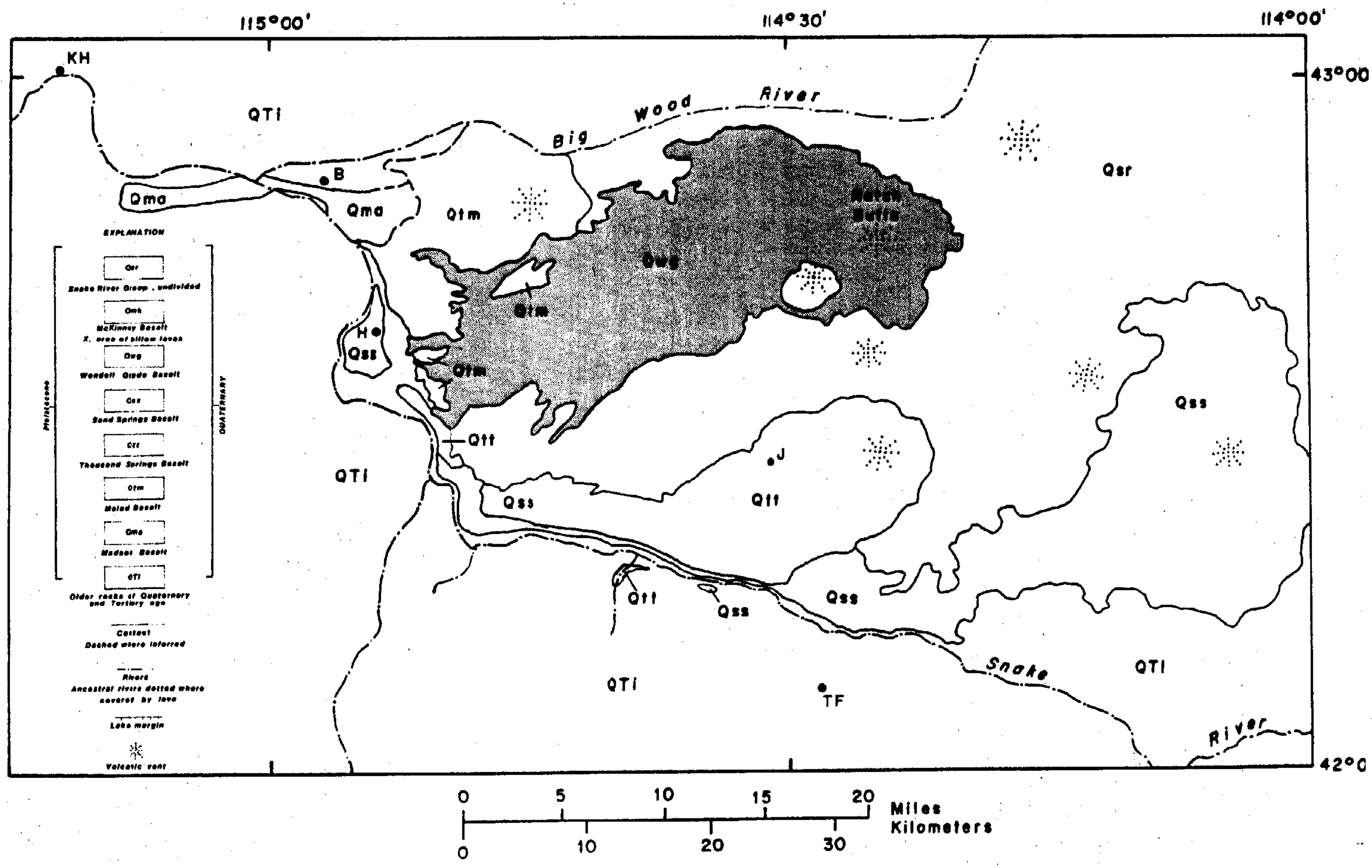


FIGURE 7E.--Wendell Grade Basalt, from vent at Notch Butte, flows westward to cascade into Billingsley Creek east of Hagerman. Not a canyon filling flow.

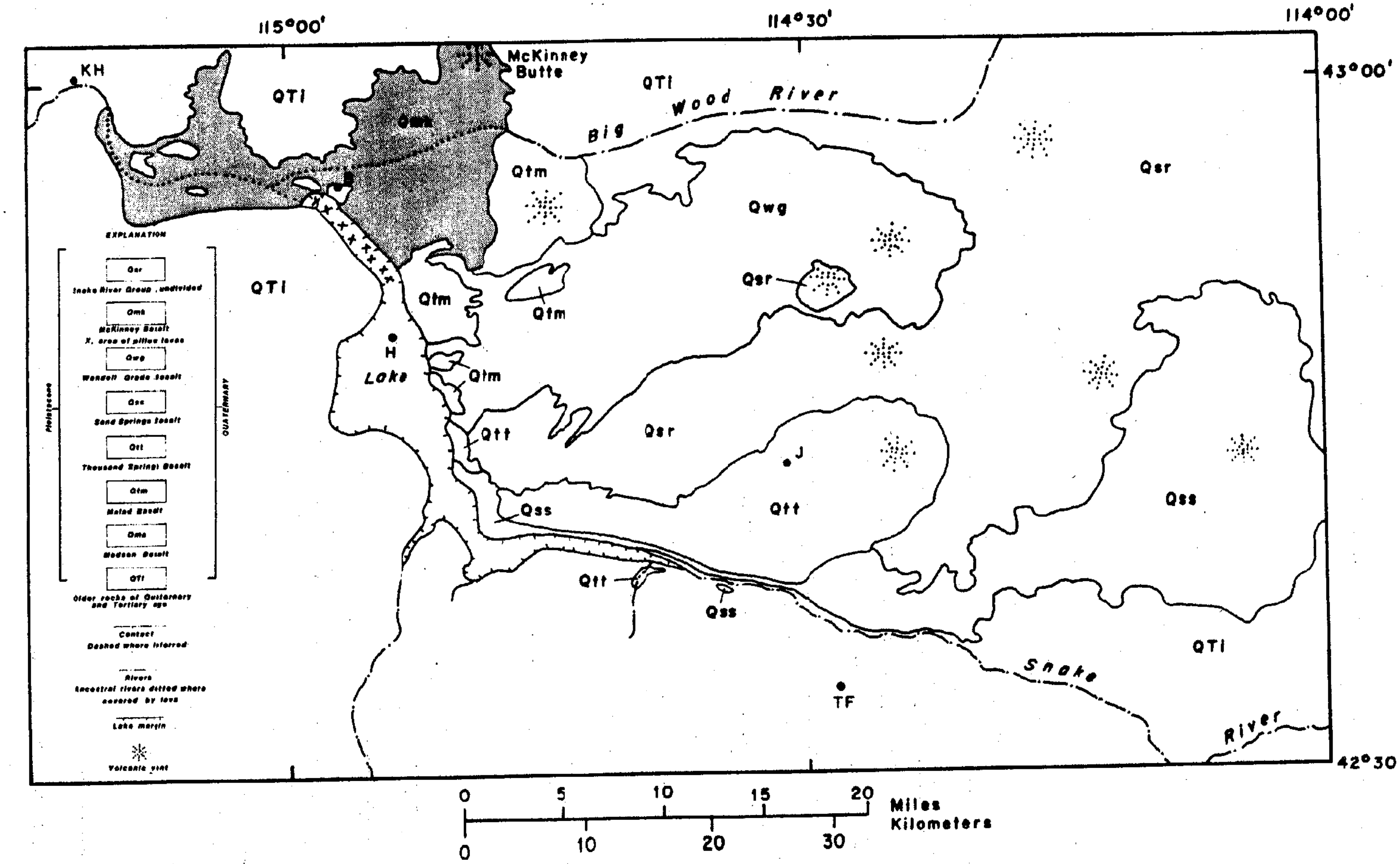


FIGURE 7F.--McKinney Basalt from vent at McKinney Butte fills ancestral Big Wood River and Snake River canyons. Diverts Big Wood River eastward and Snake River southward. Forms pillow lava facies where lava cascades into deep lake east of Bliss.